Status of Unit 1 PCV internal investigation

May 26, 2022

International Research Institute for Nuclear Decommissioning
Tokyo Electric Power Company Holdings, Inc.

1. Overview of PCV internal investigation

- Unit 1 Primary Containment Vessel (hereinafter referred to as, “PCV”) internal investigations was planned to conduct from X-2 penetration
- Six type of Investigation device used for PCV internal investigation was developed for preliminary measures when swimming in the water inside the PCV, and for investigations.
- Uses of each submersible ROV
  - ① ROV-A for guide ring installation as a preliminary measure
  - ② ROV-A2 for detailed visual investigation of the inside and the perimeter of the pedestal
  - ③ ROV-C for measure the thickness of deposits
  - ④ ROV-D for detect deposit debris
  - ⑤ ROV-E for sampling debris
  - ⑥ ROV-B for create 3-D maps of the deposits

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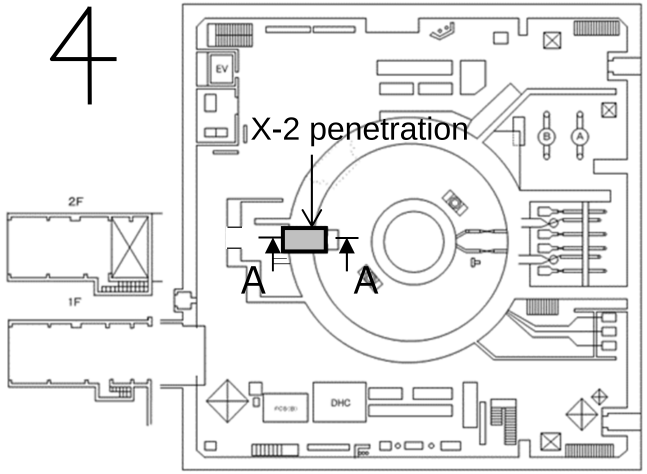
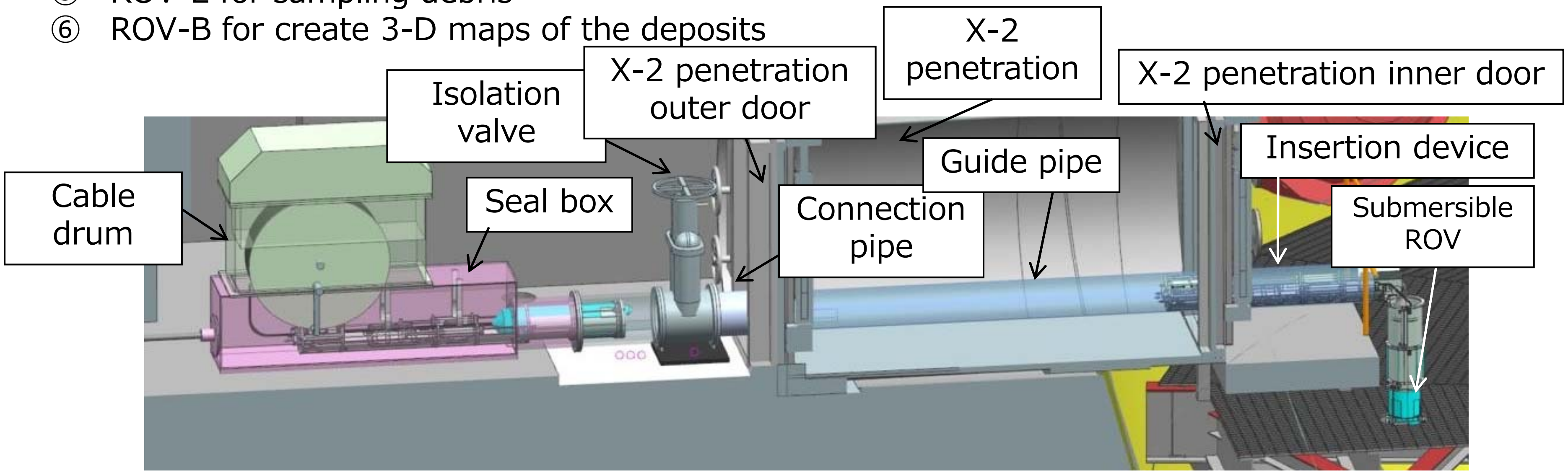


Location of X-2 penetration on the ground floor of Unit 1 reactor building



Concept diagram of internal investigation (Direction of A-A)

Source: International Research Institute for Nuclear Decommissioning (IRID)

2． Overview of PCV internal investigation

- On March 14 we began a detailed visual inspection of the outside perimeter of the pedestal using ROV-A2, but the inspection was temporarily suspended when we noticed that the water level in the PCV was dropping following the earthquake that occurred on March 16, which was assumed to be the cause.
- Since March 23, we had been continually adjusting the flow of cooling water injected into the reactor to secure the water level required for the investigation, however on March 29 we found that the video quality from cameras on the submersible ROV was poor (assumed to be caused by the intrusion of water) and suspended the investigation again.
- Until April 15 we investigated the cause of the flooding of the ROV-A2 while at the same time preparing to replace it with a spare.
- From May 9 we adjusted the flow of cooling water injected into the reactor in order to secure the water level in the PCV required to recommence the investigation, and by March 16 we had secured the required PCV water level, so the investigation was recommenced on May 17.
- The planned investigation was completed on May 22, so the unit was uninstalled on the 23rd, the next day.
- We are currently adjusting procedures in preparation for insertion of ROV-C, the next rover to be used, and will commence deposit thickness measurements using ROV-C as soon as preparations have been completed.

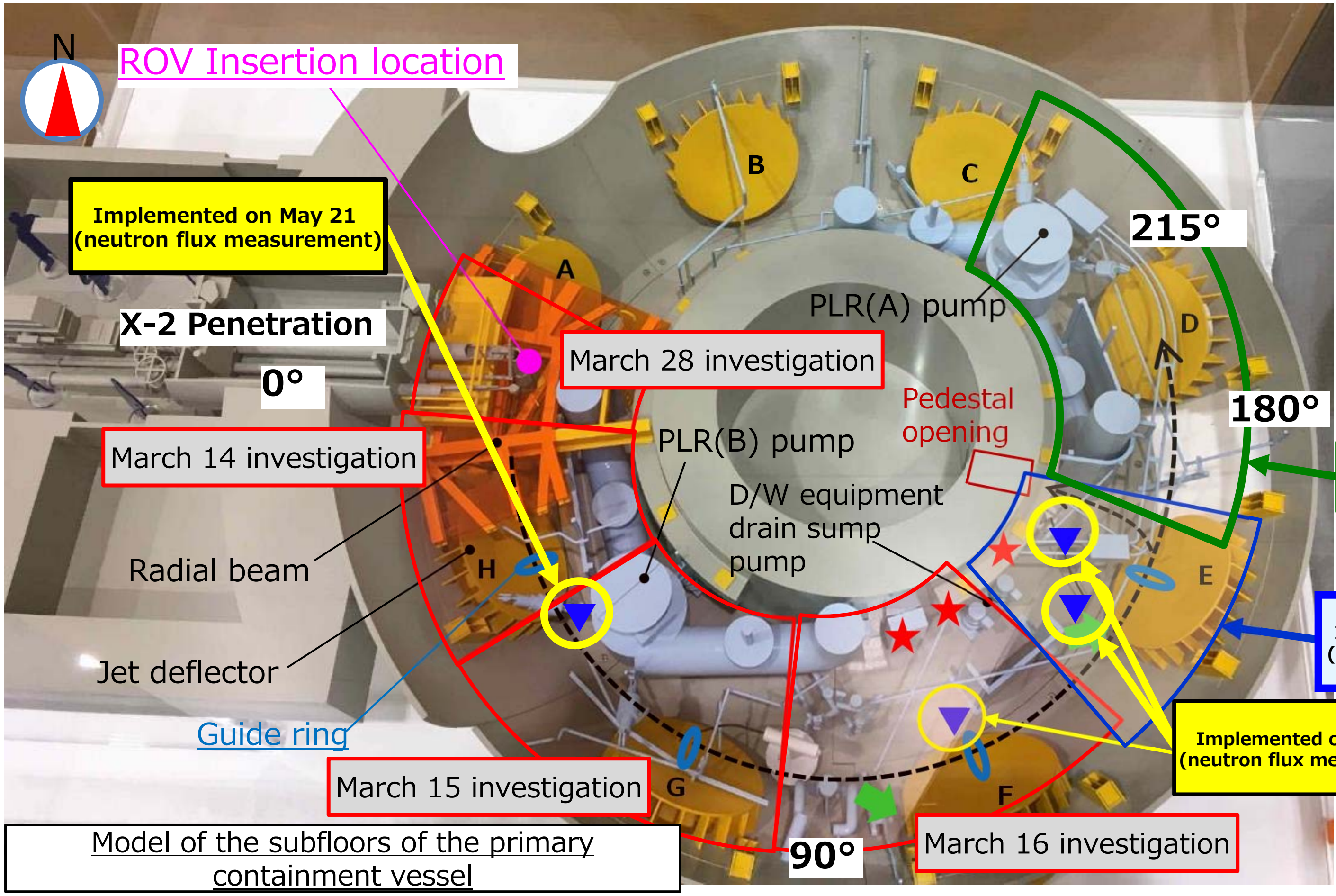
Source: International Research Institute for Nuclear Decommissioning (IRID)

3. Overview and results of ROV-A2 investigation

■ The investigation area was set from 0° to 215° (including the pedestal opening) on the basement floor of PCV and visual investigation using camera was planned

＜ Main targets of the investigation ＞

- ➢ Examine the condition of existing structures and the extent of dispersal of debris, debris height, and slope
- ➢ Examine the conditions around the pedestal opening and also the condition of the concrete wall near the pedestal opening（★Location）
- ➢ Condition of deposits around the jet deflectors（⬇Location）
- ➢ Measure neutron flux above deposits（▼ Location）



Model of the subfloors of the primary containment vessel

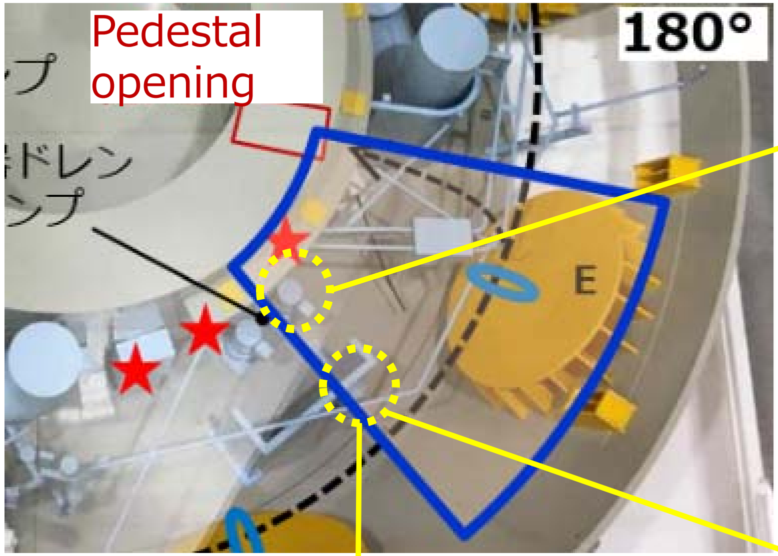
※ Originally measurements were to be taken near the ROV insertion point, but tension in the ROV cable prevented stable hovering of the ROV at this location and required that a change be made to the measurement point.

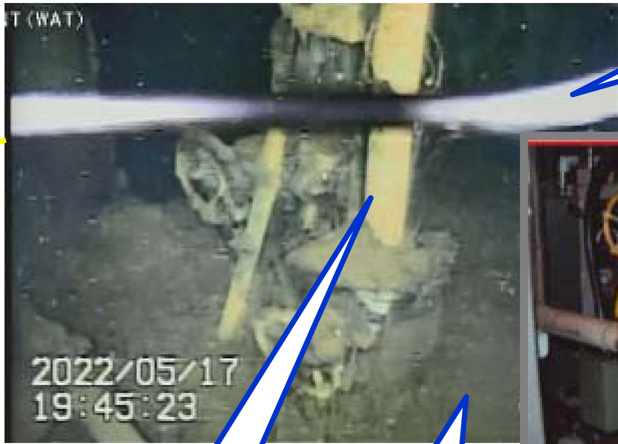
Source : International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 19, 2022

Conditions near the equipment drain sump pump and bottom of the PCV (from investigation on May 17 ①)





(Reference photo) conditions prior to the accident in 2011

Photo 1. Conditions near the equipment drain sump pump

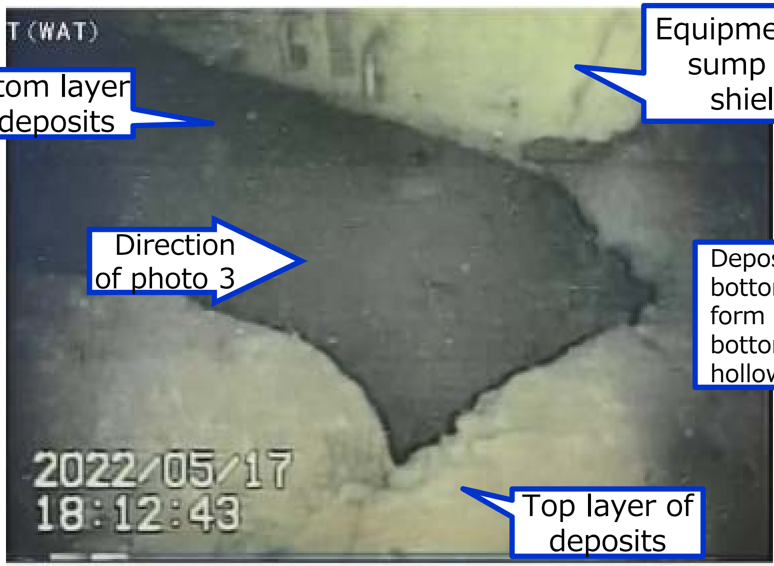


Photo 2. Deposits at the bottom of the PCV

Photo 3. Deposits at the bottom of the PCV (hollow area)

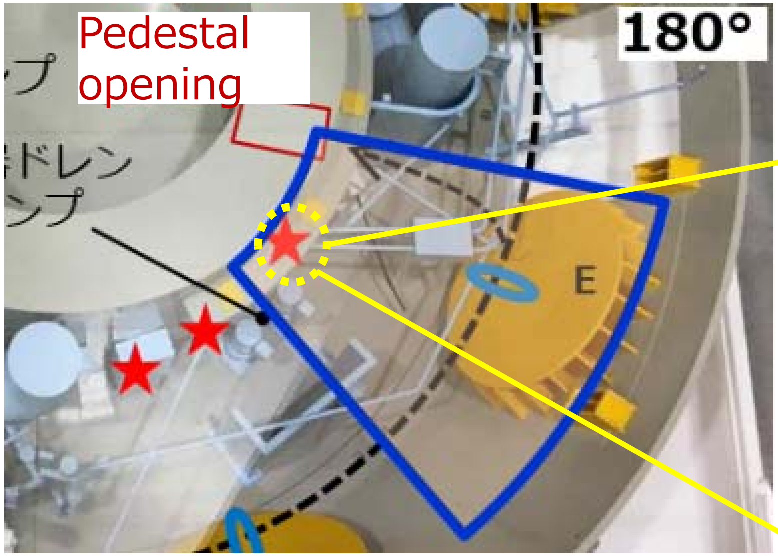
Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 19, 2022

IRID TEPCO

Conditions around the pedestal (from investigation on May 17 ②)



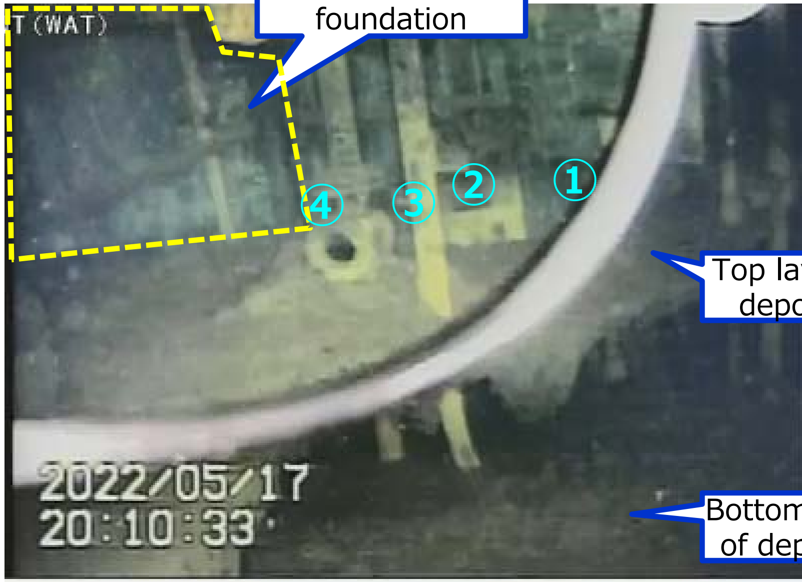


Photo 1. Conditions at top of pedestal foundation

(Reference photo) conditions prior to the accident in 2011

(Reference)
①Cable relay box (A)
②Cable relay box (B)
③Square support box
④ Reactor venting pipe sight glass

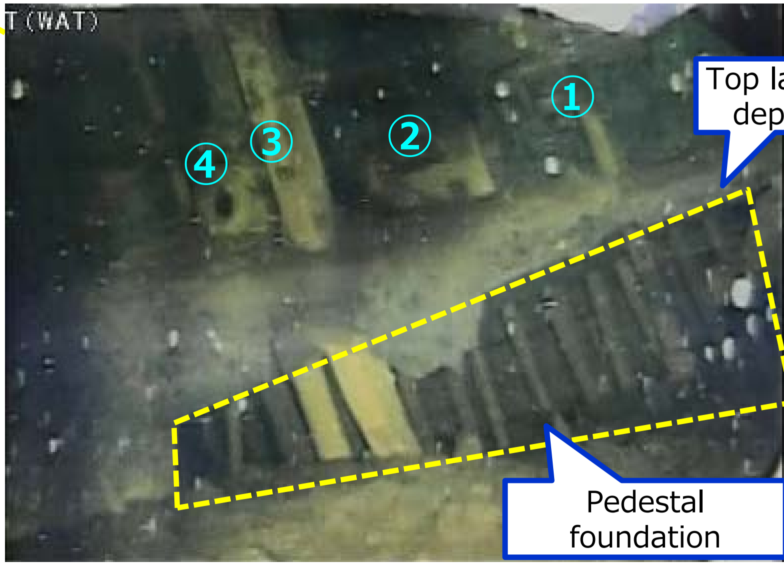


Photo 2. Conditions at bottom of pedestal foundation

Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 19, 2022

IRID TEPCO

Comparison with conditions prior to the March 16 earthquake around jet deflector F (from investigation on May 17 ③)

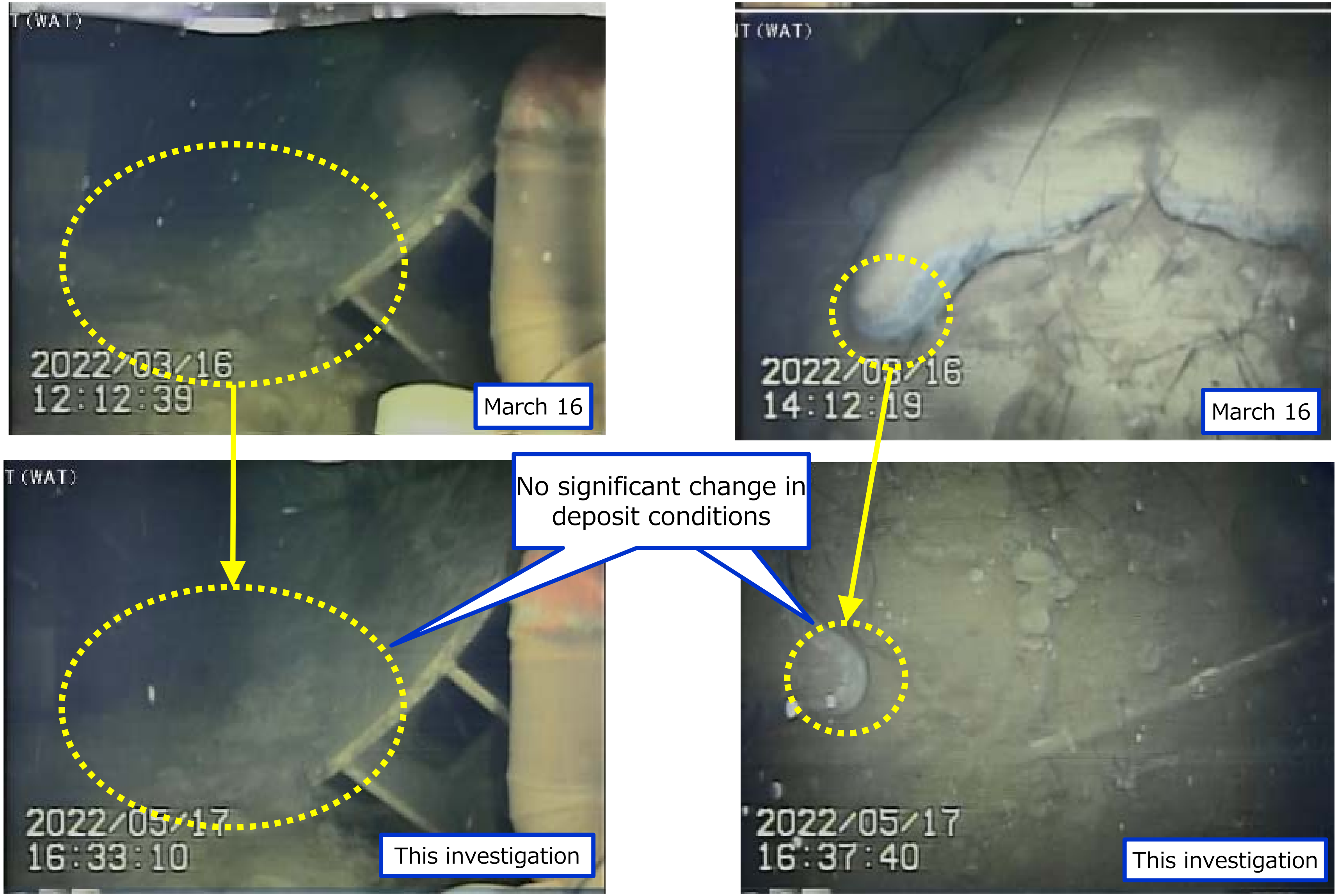


Photo 1. Looking down on jet deflector (F)

Photo 2. Conditions around jet deflector (F)

Source: International Research Institute for Nuclear Decommissioning (IRID)

4． Investigation results

Announced by May 19, 2022

Conditions around jet deflector (E)
(from investigation on May 17 ④ and May 18 ①)

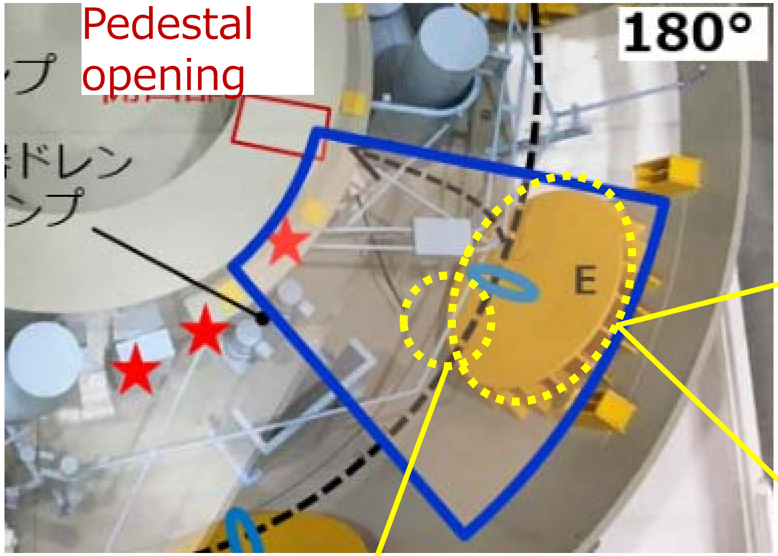


Photo 1. Looking down on jet deflector (E)

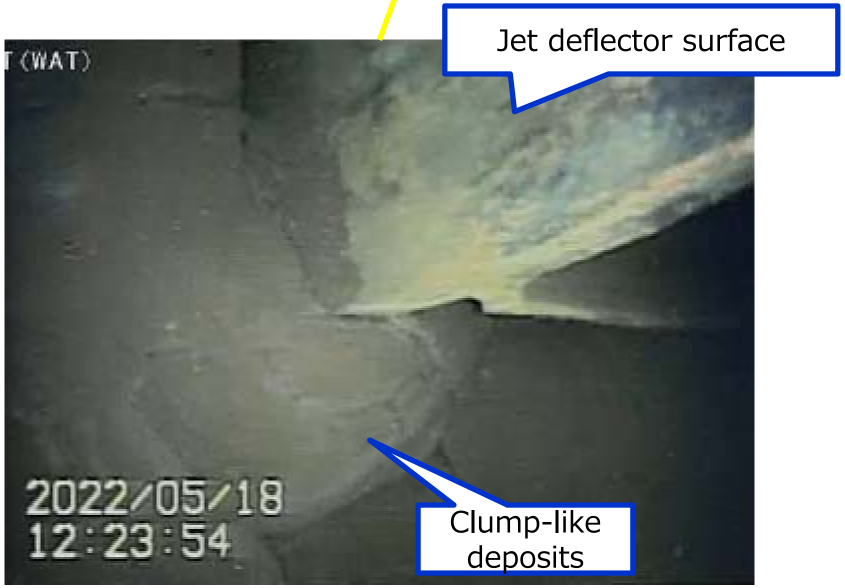


Photo 2. Conditions at the bottom front of jet deflector (E)

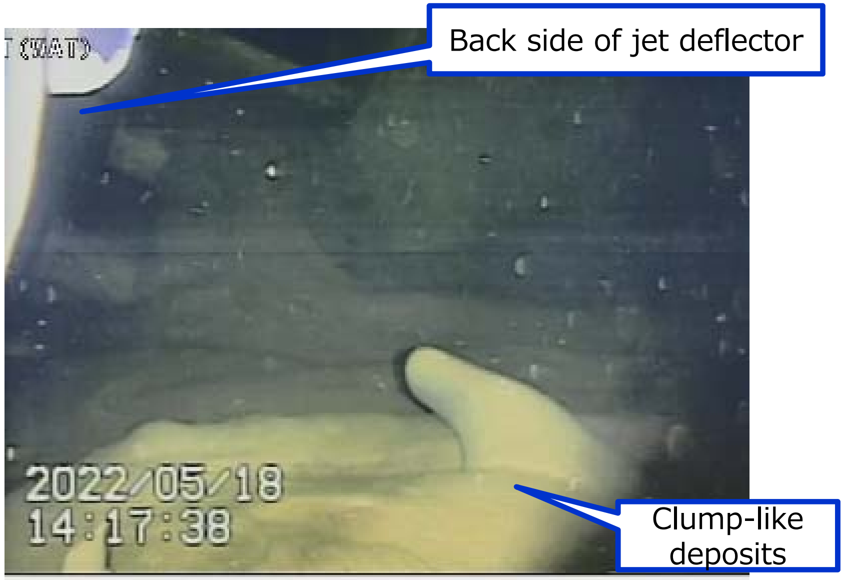


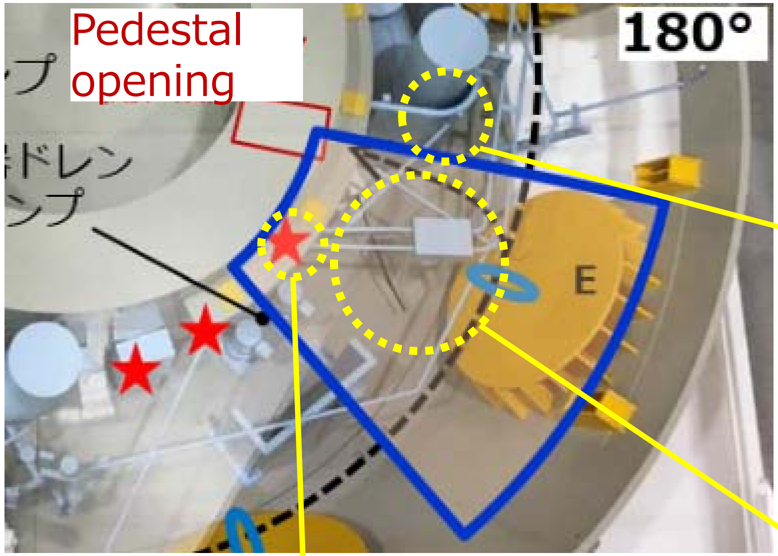
Photo 3. Conditions at the back of jet deflector (E)

Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Conditions around the PLR (A) pipe and pedestal
(from May 18 investigation②)

Announced by May 19, 2022



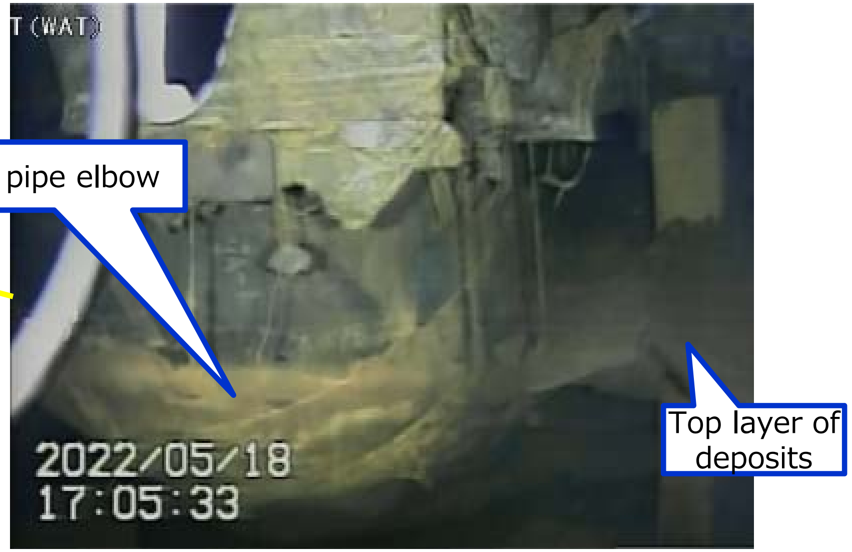


Photo 1. PLR (A) pipe conditions

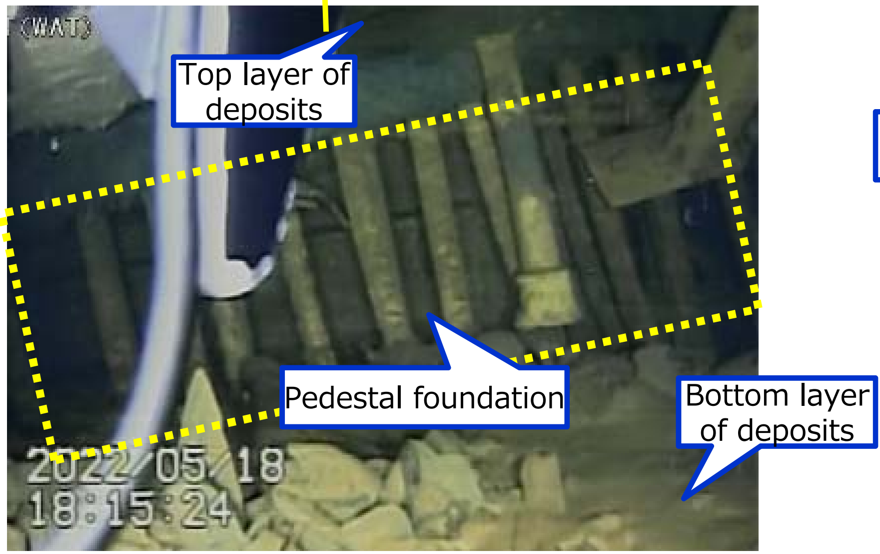


Photo 2. Conditions around the pedestal foundation

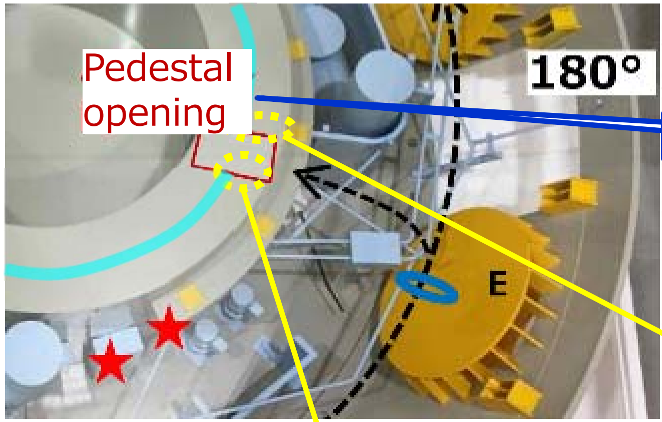
Photo 3. Deposits in front of the pedestal opening

Source: International Research Institute for Nuclear Decommissioning (IRID)

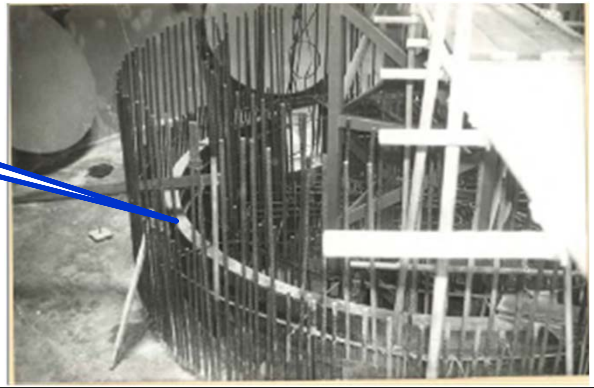
4. Investigation results

Conditions around the pedestal opening (foundation) (from investigation on May 19 ①)

- ✓ Close up photos of the rebar-like objects were compared with photos taken at the time of construction and it was determined that the objects are indeed rebar from the pedestal. The inner skirt※ was also observed
- ✓ A post-accident (FY2016) assessment of the seismic resistance of the Unit 1 reactor pressure vessel and primary containment vessel confirmed that even though part of the pedestal is damaged, it is adequately supported
- ✓ In light of the results of this investigation, we shall acquire more data going forward and conduct another assessment



※Inner skirt: Steel cylinder located inside the pedestal (on the inside of the rebar) that transfers the load of the pedestal to the bottom of the PCV (foundation mat)



(Reference photograph) Photos from construction

Photo 1. Conditions at the pedestal opening (left side foundation)

Photo 2. Conditions at the pedestal opening (right side foundation)

Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 23, 2022

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Conditions around the pedestal opening (foundation) (from investigation on May 19 ②)

- ✓ Pedestal rebar was found at the bottom the deposits
- ✓ At the top of the deposits we found the pedestal foundation intact

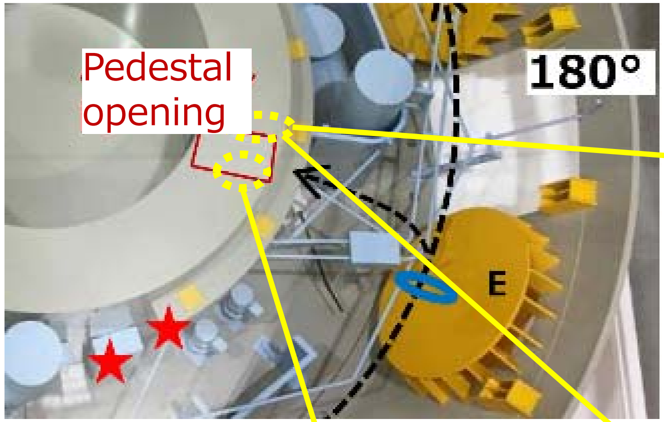


Photo 1. Conditions above the deposits at the opening of the pedestal (right side foundation)

Photo 2. Conditions above and below the deposits at the pedestal opening (left side foundation)

Photo 3. Conditions at the bottom of the deposits at the pedestal opening (right side foundation)

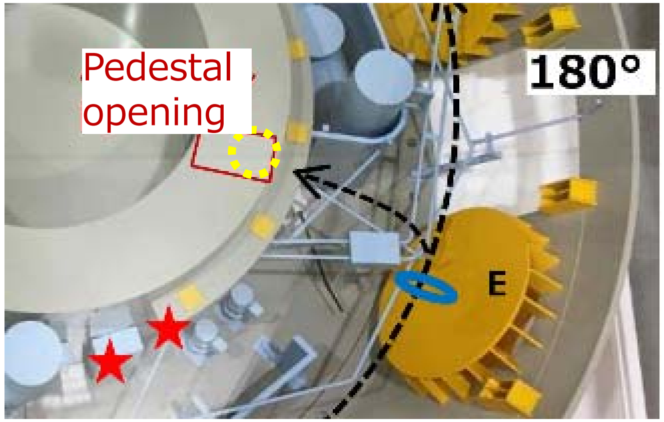
Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 23, 2022

Pedestal opening (inside nearest to the ROV) conditions (from investigation on May 19③)

✓ Several clump-like deposits were found



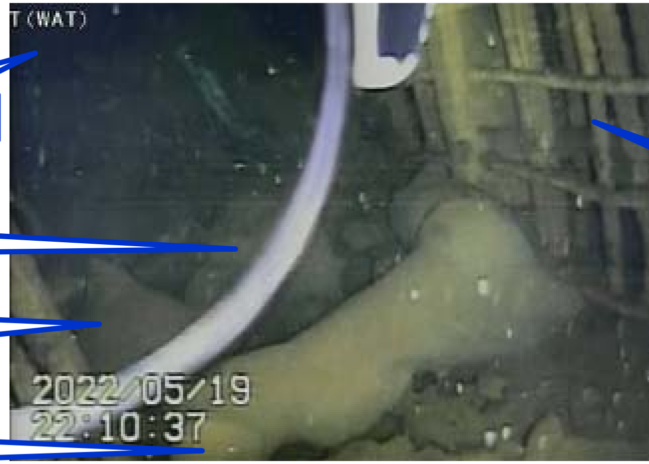


Photo 1. Looking down on the pedestal opening (inside nearest to the ROV)

Photo 2. Conditions at the pedestal opening (inside nearest to the ROV)

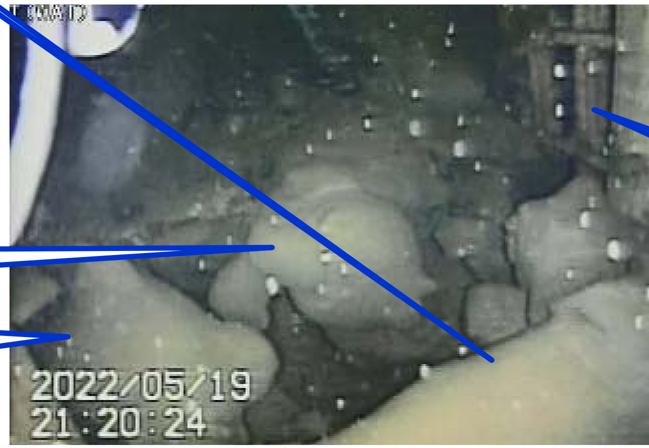


Photo 3. Conditions at the pedestal opening (inside nearest to the ROV)

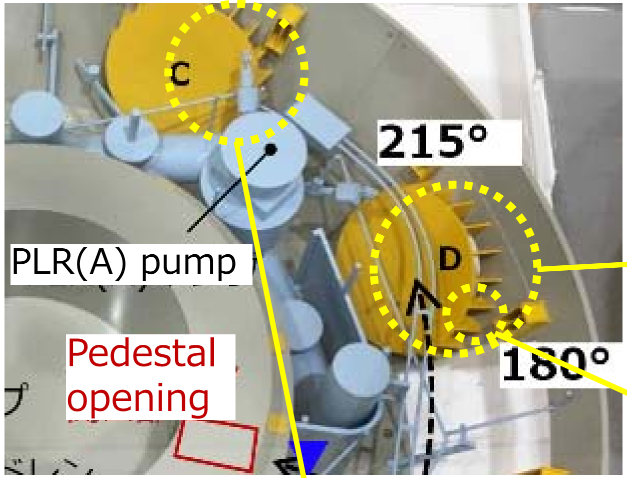
Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation results

Announced by May 23, 2022

Conditions around jet deflector (C and D) (from investigation on May 19 ④)

- ✓ Deposits were found around Jets deflector (D) and behind it (pressure suppression chamber side)
- ✓ Deposits were found around Jets deflector (C)



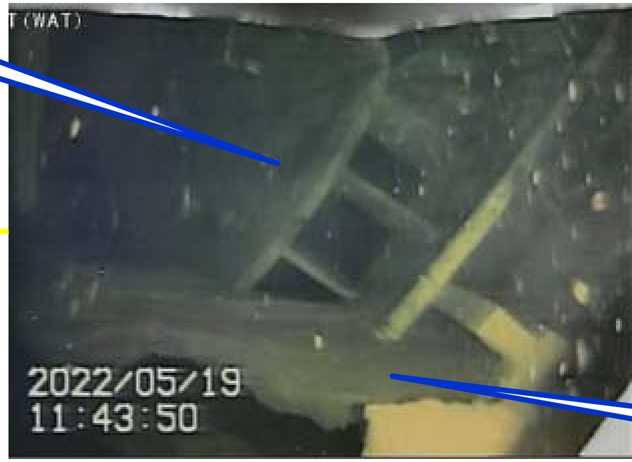


Photo 1. Looking down on jet deflector (D)

Photo 2. Looking down on jet deflector (C)

Photo 3. Conditions at the back of jet deflector (D)

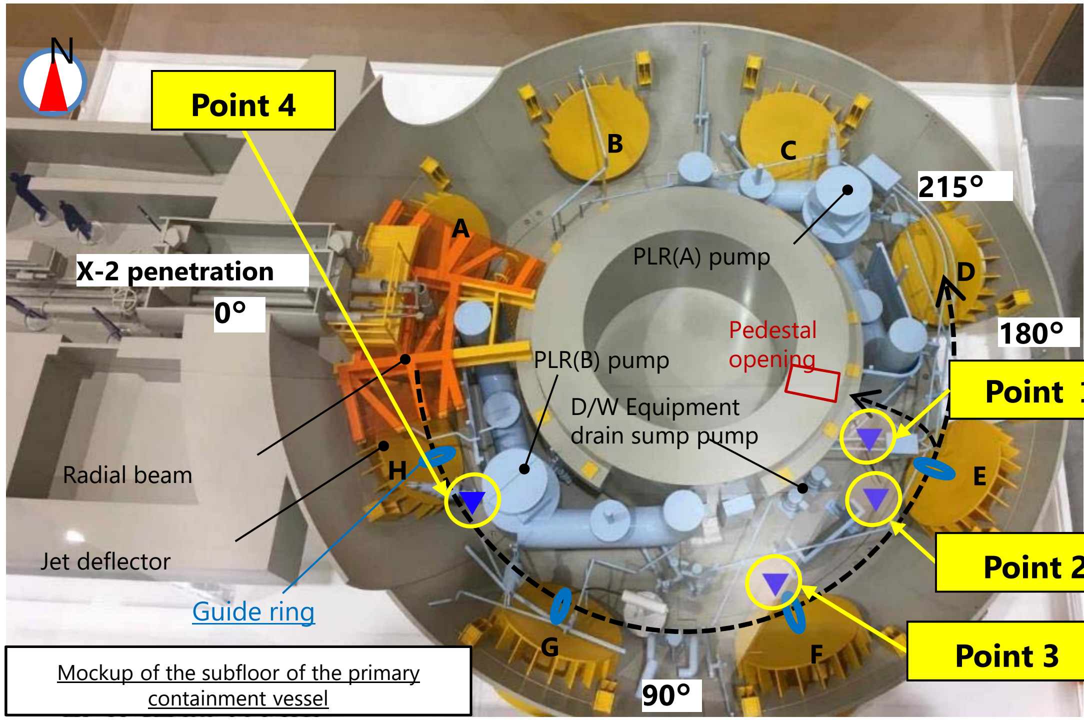
Source: International Research Institute for Nuclear Decommissioning (IRID)

4. Investigation Results

Neutron flux measurement results (from investigations on May 20 and 21)

IRID TEPCO

- Thermal neutron flux was observed at all measurement points.
- Since a lot of thermal neutron flux was observed near the pedestal opening, fuel debris is assumed to be the origin.
- Going forward, the next rover to be used, ROV-C (deposit thickness measurement), will measure the height and thickness of deposits after which ROV-D (fuel debris detection) will be used to look for the presence of fuel debris in the deposits.



Mockup of the subfloor of the primary containment vessel

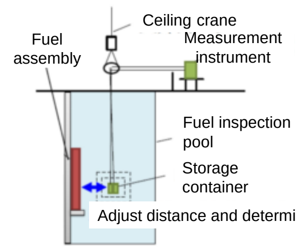
Measurement point	Point 1	Point 2	Point 3	Point 4
Thermal neutron flux[/cm2/ s]	48.0	29.1	50.2	5.8

- Thermal neutron flux is the sum of the distance traveled by thermal neutrons within a certain unit of volume in a certain unit of time.
- Measurements are performed for 60 minutes at one location.
- Measurement results are expressed as thermal neutron flux assessed from the number of thermal neutrons counted during that 60 minute period.

<Reference> Fuel assembly measurement result @NFD from B10 detector attached to ROV-A

■ Measurement method

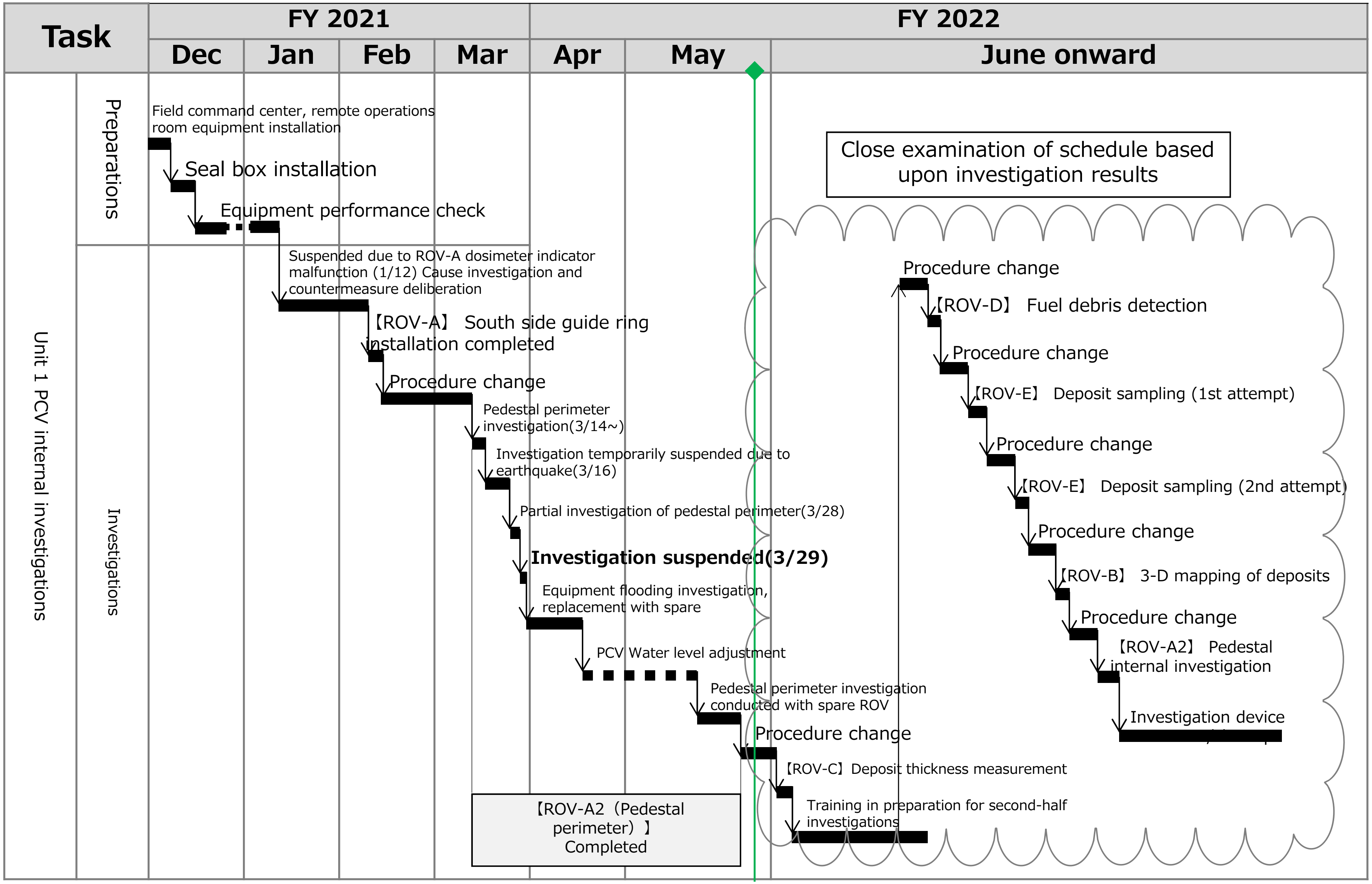
- Positioned at the center of the fuel in the axial direction
- Measured at 3 positions including the position closest to the fuel (Dose rates: 14.4, 6.5, 1.5Gy/h)
- Measurement time: 3 min.



Dose rate	Source-detector distance	Thermal neutron flux assessment value
14.4 Gy/h	Approx. 16 cm	8.8×10^{1} /cm²/s
6.5 Gy/h	Approx. 16 cm	1.1×10^{1} /cm²/s
1.5 Gy/h	Approx. 16 cm	0 /cm²/s

Source: International Research Institute for Nuclear Decommissioning (IRID)

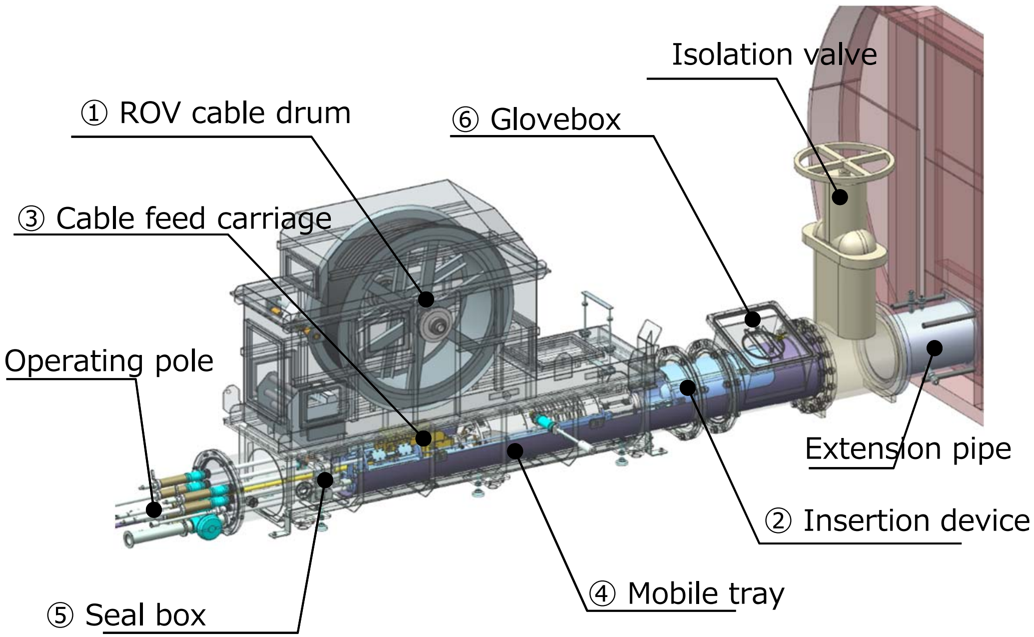
5． Schedule going forward

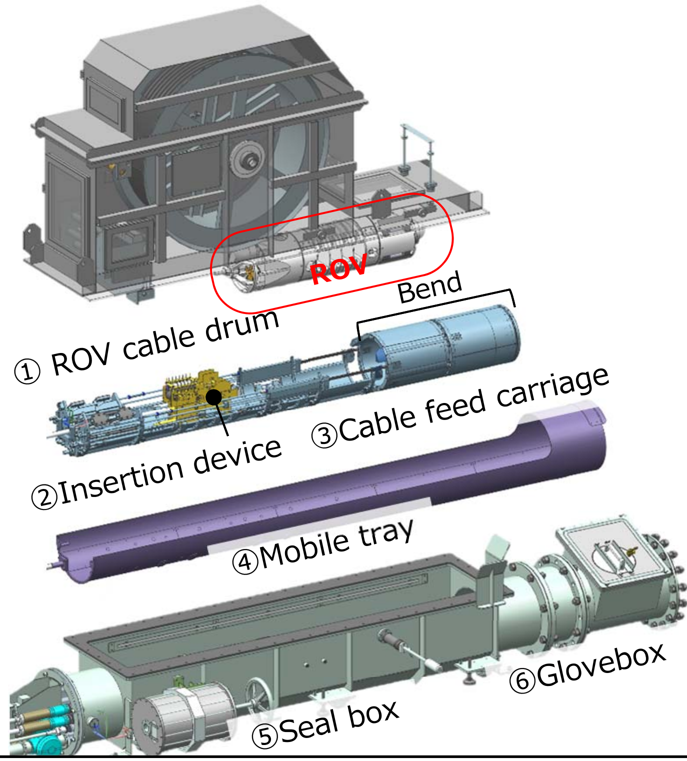


(Note) Task implementation timing may be altered in conjunction with the progress of other fieldwork

(Reference) Investigation device details
Seal box and other equipment

Inserts/extracts the ROV into/from the PCV.
Creates a PCV boundary along with the ROV cable drum.





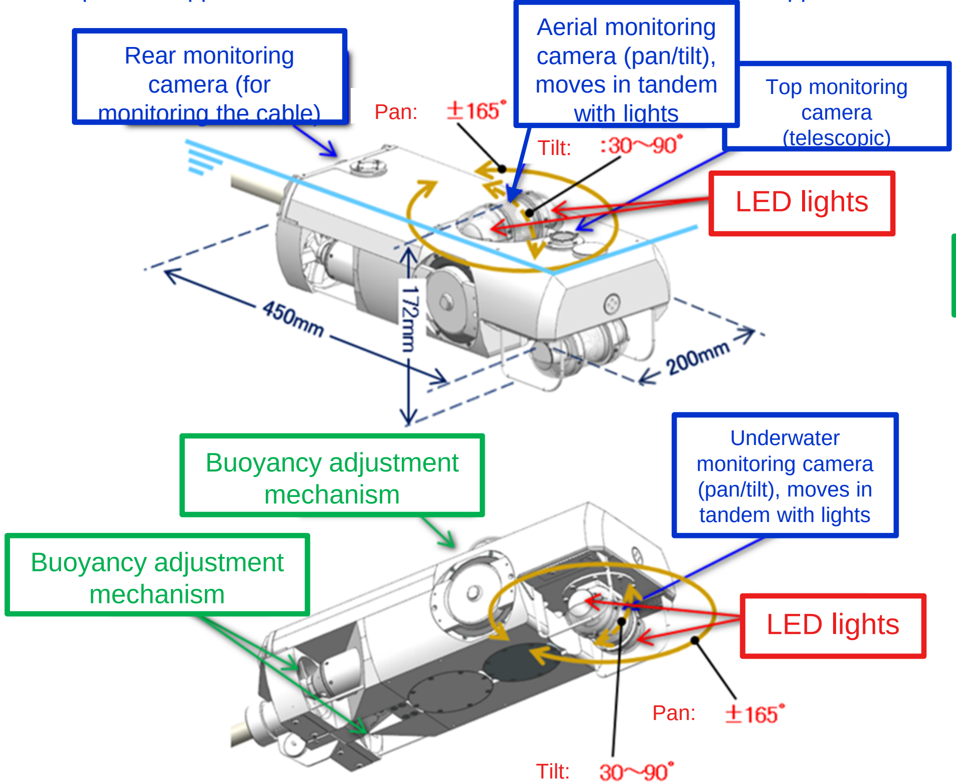
Name of component		Role
①	ROV Cable drum	Part of the ROV that feeds and retracts the ROV cable.
②	Insertion device	Inserts the ROV into the PCV via guide rings and bends to stand the ROV vertically once inside.
③	Cable feed carriage	Works in tandem with the cable drum to assist with the cable.
④	Mobile tray	Device for carrying the insertion device up to the guide pipe.
⑤	Seal box	Houses the ROV cable drum and constitutes a boundary.
⑥	Glovebox	Used to set the cable fee carriage and to cut the cable in the event of an emergency.

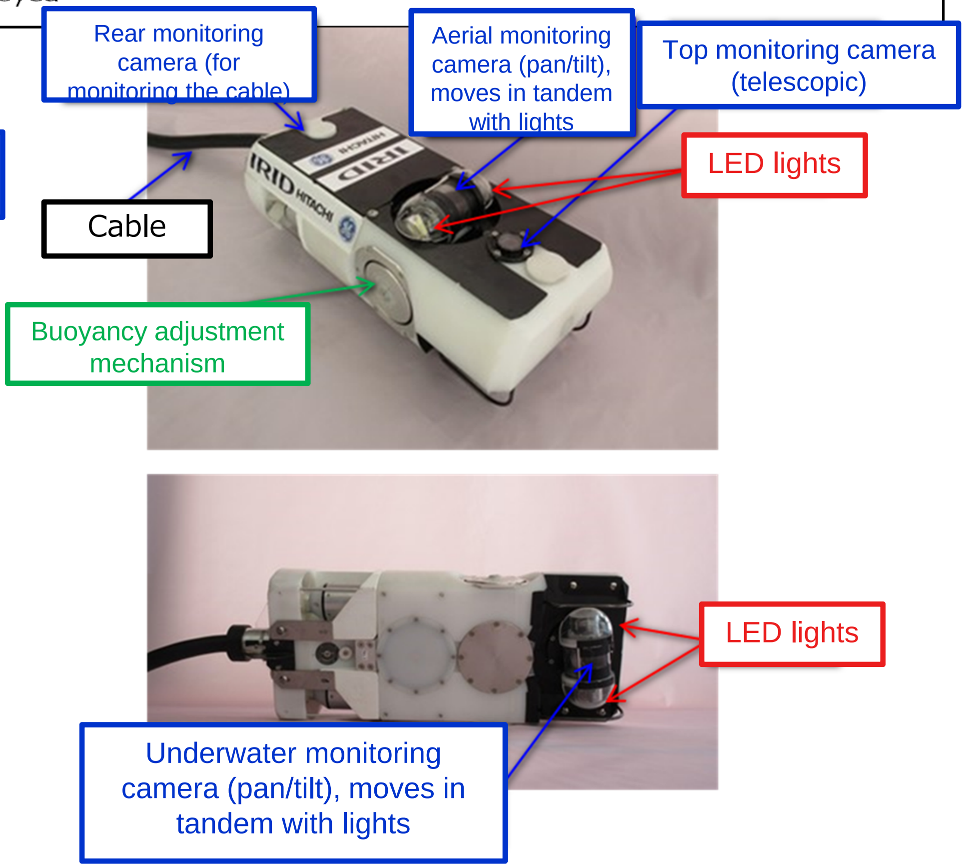
Source: International Research Institute for Nuclear Decommissioning (IRID)

(Reference) Investigation device details
ROV-A2 for detailed visual investigation

Investigation device	Instruments	Details
ROV-A2 Detailed visual investigation	ROV protection (Fiber-optic γ-ray dosimeter※, Improved mini B10 detector) ※ : Same as that used for the external investigation of the pedestal	Uses cameras to perform a visual investigation of the extensive basement area and of the status of the detached CRD housing inside the pedestal (※) (※If it can be accessed)
	Quantity: 2 units; Cruising time: Approx. 80 hours/unit Since the units need to be agile for the investigation flexible PVC cables (φ23mm) will be employed	

Propulsion: Approx. 50N Dimensions: Diameter: 20cm x Length: Approx. 45cm

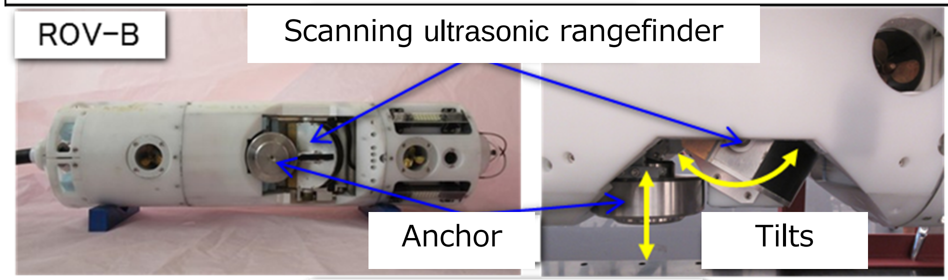


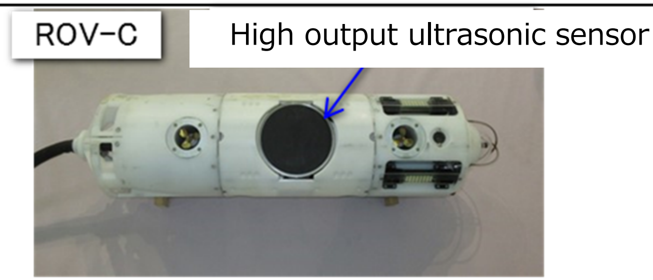


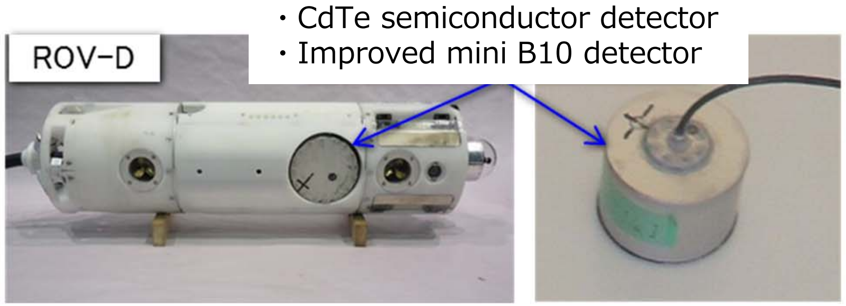
Source: International Research Institute for Nuclear Decommissioning (IRID)

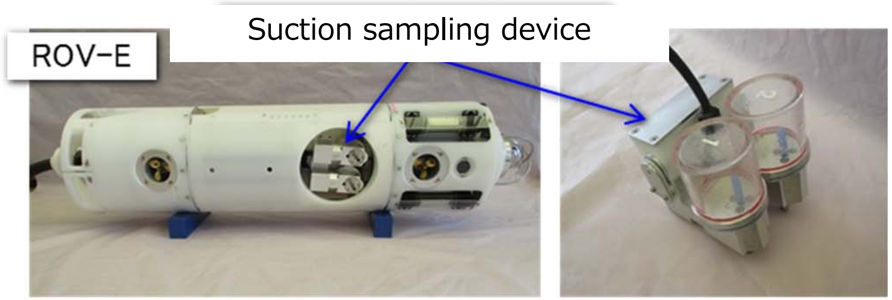
(Reference) Investigation device details
ROV-B~E for different investigations

Investigation device	Instruments	Details
ROV-B 3-D mapping of deposits	・Scanning ultrasonic rangefinder ・Water temperature gauge	Scanning ultrasonic rangefinder used to examine the height distribution of deposits.
ROV-C Deposit thickness measurements	・High output ultrasonic sensor ・Water temperature gauge	High output ultrasonic sensor used to measure the height of deposits and examine objects underneath them in order to estimate debris height and distribution.
ROV-D Deposit debris detection	・CdTe semiconductor detector ・Improved mini B10 detector	Debris detection sensors will be dropped on the surface of the deposits to analyze nuclides and measure neutron flux in order to examine if debris exists inside the deposits.
ROV-E Deposit sampling	・Suction sampling device	The deposit sampling device will be dropped on the surface of the deposits to take samples from the surface of the deposits.
Quantity: 2 each; Cruising time: Approx. 80 hours/unit Since the units need to be agile for the investigations flexible PVC cables (ROV-B : φ33mm、ROV-C : φ30mm、ROV-D : φ30mm、ROV-E : φ30mm) will be employed		









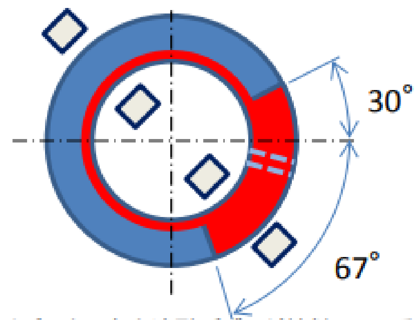
Source: International Research Institute for Nuclear Decommissioning (IRID)

(Reference) IRID Pedestal seismic resistance/impact assessment

- In FY2016, the International Research Institute for Nuclear Decommissioning (IRID) conducted a seismic resistance/impact assessment of the pressure vessel and primary containment vessel as part of the government-funded Decommissioning/Contaminated Water Project
- Upon assessing the seismic resistance of the concrete and rebar of the pedestal, of which a portion has degraded/been damaged as a result of high temperatures, it was confirmed that resistance values are below the base values for commercial nuclear reactor facilities and concrete primary containment vessels stipulated by the Japan Society of Mechanical Engineers.

Assessment result summary

Case	Temperature	Debris erosion	Assessment target	Initiation stress/strain (A)	Assessment base value (B)	A/B
No.1	Inside: 800℃ Outside: 800℃	No	Concrete strain	305μ	3000μ	0.10
			Rebar strain	155μ	5000μ	0.03
			Outer surface shear stress	0.23 N/mm²	1.28 N/mm²	0.18
No.2	Inside: 1200℃ Outside: 600℃	〃	Concrete strain	671μ	3000μ	0.22
			Rebar strain	286μ	5000μ	0.06
			Outer surface shear stress	0.39 N/mm²	1.20 N/mm²	0.33
No.3	〃	Yes	Concrete strain	1246μ	3000μ	0.42
			Rebar strain	652μ	5000μ	0.13
			Outer surface shear stress	0.69 N/mm²	1.44 N/mm²	0.48



It is assumed that portions of the RPV pedestal that came in contact with molten debris are damaged

Source:
FY2014 supplementary budget decommissioning/contaminated water project subsidies
Pressure vessel/containment vessel seismic resistance/impact assessment method development FY2016 results report
International Research Institute for Nuclear Decommissioning (IRID)
https://irid.or.jp/wp-content/uploads/2017/06/20160000_11.pdf